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# LT3761EMSE
## High Voltage LED Controller
## with Internal PWM Dimming

# DESCRIPTION

DC1772A is a high voltage LED controller with internal PWM dimming. It generates its own PWMOUT waveform for accurate PWM dimming with up to 25:1 brightness ratio. It accepts an input voltage from 8V to 60V (8V UVLO and 9.1V rising turn-on), and drives up to 60V of LEDs at 1A (when PVIN is less than $V_{LED}$). DC1772A features both PWM and analog dimming of the LED string. It has an $\overline{OPENLED}$ flag that indicates when the LED string has been removed.

DC1772A features high efficiency at 350kHz switching frequency. At high LED string voltages up to 60V and 1A of LED current, the single switch controller has 94% efficiency. The open LED overvoltage protection uses the IC's constant voltage regulation loop to regulate the output to approximately 69.8V if the LED string is opened although it may reach 74V peak during transient from running LEDs to open. The maximum LED string voltage can be raised from 60V to 65V (or higher) with a simple change of feedback resistors.

For low input voltage operation, the CTRL pin voltage is reduced as the input voltage drops below 10V, reducing LED brightness and restraining the peak switch currents in order to limit inductor and switch size. UVLO turns the LEDs off when PVIN drops below 8V.

DC1772A PWM dimming is simplified when compared with other LED drivers. The LT®3761 generates its own PWMOUT dimming waveform at a frequency determined by the capacitance on the PWM pin (C8 gives 300Hz for DC1772A). The PWMOUT duty cycle is determined by the voltage on the DIM terminal. Between 0V and 7.7V VDIM gives between 4% and 96% PWM duty cycle. Information regarding PWM dimming ratios and performance can be found in the LT3761 data sheet in the Applications Information section. Analog dimming is also simple to use with a single voltage source on the CTRL terminal.

Modifications can be made to DC1772A in order to convert the board to higher or lower power or from an LED driver to a constant voltage regulator or battery charger. It can easily be changed from a boost topology to a SEPIC, buck mode, or buck-boost mode LED driver. Please consult the factory or the LT3761 data sheet for details. It can be modified to provide LED+ to GND short-circuit protection as well.

The LT3761 data sheet gives a complete description of the part, operation and applications information. The data sheet must be read in conjunction with this demo manual for demonstration circuit DC1772A. The LT3761EMSE is assembled in a 16-lead plastic MSOP MSE package with a thermally enhanced ground pad. Proper board layout is essential for maximum thermal performance. See the data sheet section Layout Considerations.

**Design files for this circuit board are available at http://www.linear.com/demo**

# PERFORMANCE SUMMARY    Specifications are at $T_A = 25°C$

| PARAMETER | CONDITION | VALUE (TYPICAL) |
|---|---|---|
| Input Voltage PVIN Range | Operating | 8V to $V_{LED}$ (Up to 60V) |
| Switching Frequency | R6 = 29.4k | 350kHz |
| $I_{LED}$ | RS2 = 0.25Ω 10V < PVIN < $V_{LED}$ (60V) | 1A |
| Low PVIN $I_{LED}$ (CTRL Foldback) | RS2 = 0.25Ω PVIN = 8.5V<br>RS2 = 0.25Ω PVIN = 9V | 930mA<br>975mA |
| $V_{LED}$ Range | R3 = 1M R4 = 18.2k | PVIN < $V_{LED}$ < 60V |
| Open LED Voltage | R3 = 1M R4 = 18.2k | 69.8V |
| Typical Efficiency | PVIN = 14V $V_{LED}$ = 60V $I_{LED}$ = 1A PWM = INTVCC | 94% |
| PVIN Under Voltage Lockout (Falling Turn-Off) | R1 = 499k and R2 = 90.9k | 8V |
| PVIN Under Voltage Lockout (Rising Turn-On) | R1 = 499k and R2 = 90.9k | 9.1V |
| INTVCC | Operating | 7.85V |
| Peak Switch Current Limit | RS1 = 0.008Ω | 12.5A |
| PWMOUT Dimming Duty Cycle | VDIM = 7.7V<br>VDIM = 4V<br>VDIM = 1.5V<br>VDIM = 0.4V | 96%<br>50%<br>10%<br>4.3% |
| Internal PWM Dimming Frequency | C8 = 0.047µF 0V < VDIM < 7.7V | 300Hz |

# QUICK START PROCEDURE

Demonstration circuit 1772A is easy to set up to evaluate the performance of the LT3761EMSE. Follow the procedure below:

1. Connect a string of LEDs that will run with forward voltage less than 60V, but greater than PVIN, to the LED+ and LED– terminals on the PCB as shown in Figure 1.

2. Connect the EN/UVLO terminal to GND.

3. With power off, connect the input power supply to the PVIN and GND terminals. Make sure that the PVIN DC input voltage will not exceed 60V (or $V_{LED}$).

4. Connect the DIM terminal to a voltage between 0V and 7.7V to set the internal PWMOUT dimming duty cycle. If this terminal is left floating the converter will run with approximately 12% PWMOUT dimming duty cycle. Pull the PWM terminal high to INTVCC to set the converter at 100% duty cycle.

5. Turn the input power supply on and make sure the voltage is between 8V and 60V (or $V_{LED}$).

6. Release the EN/UVLO-to-GND connection.

7. Observe the LED string running at the programmed LED current and brightness related to the programmed PWMOUT duty cycle.

8. To change the brightness with PWM dimming, simply vary the VDIM voltage between 0V and 7.7V with the PWM terminal floating.

9. To change the brightness with analog dimming, simply attach a voltage source on the CTRL terminal and reduce the voltage below 1.2V.

10. Observe the reduction of brightness in the LED string when PWM or analog dimming.
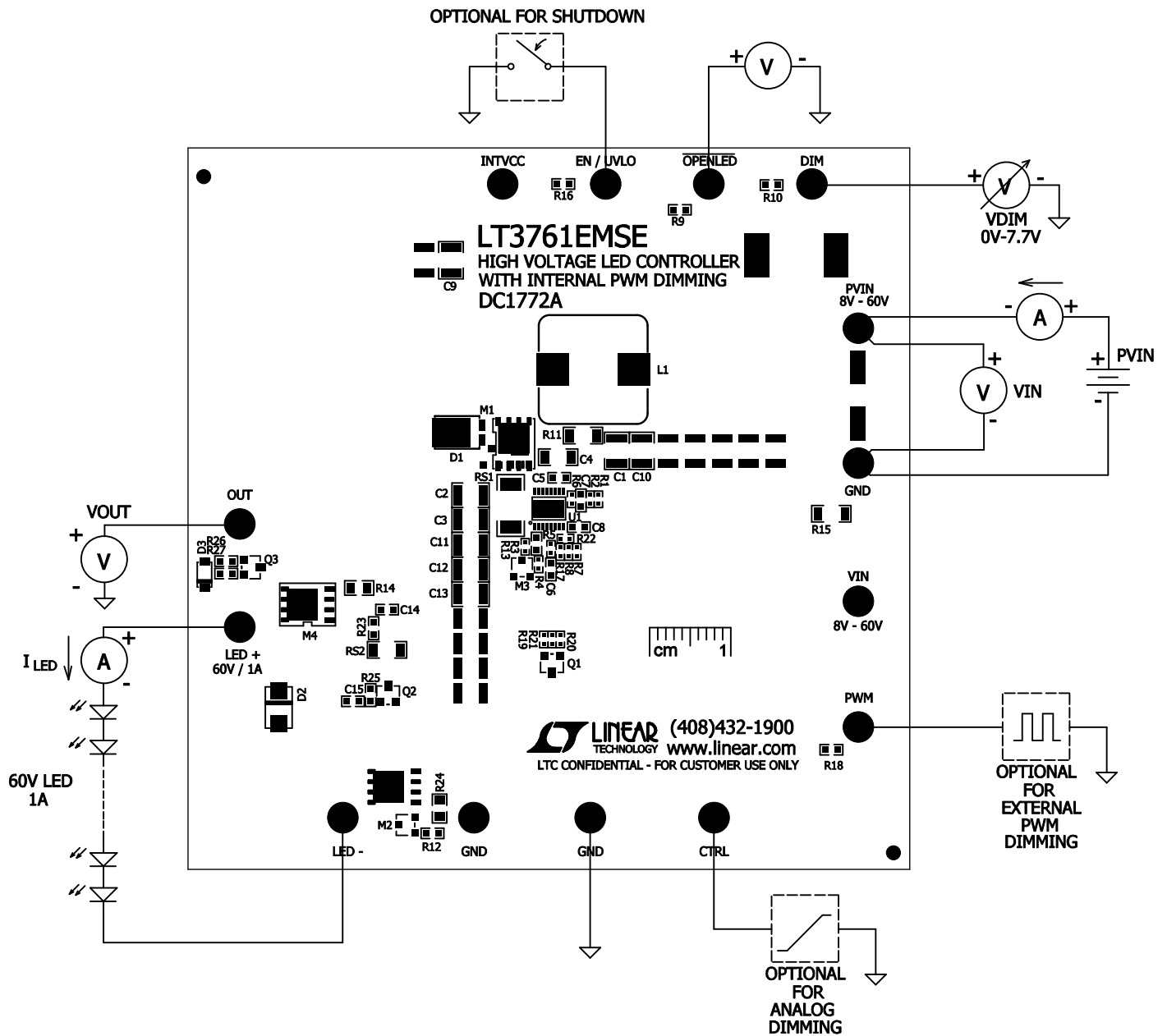
# QUICK START PROCEDURE



**Figure 1. Test Procedure Setup Drawing for DC1772A**

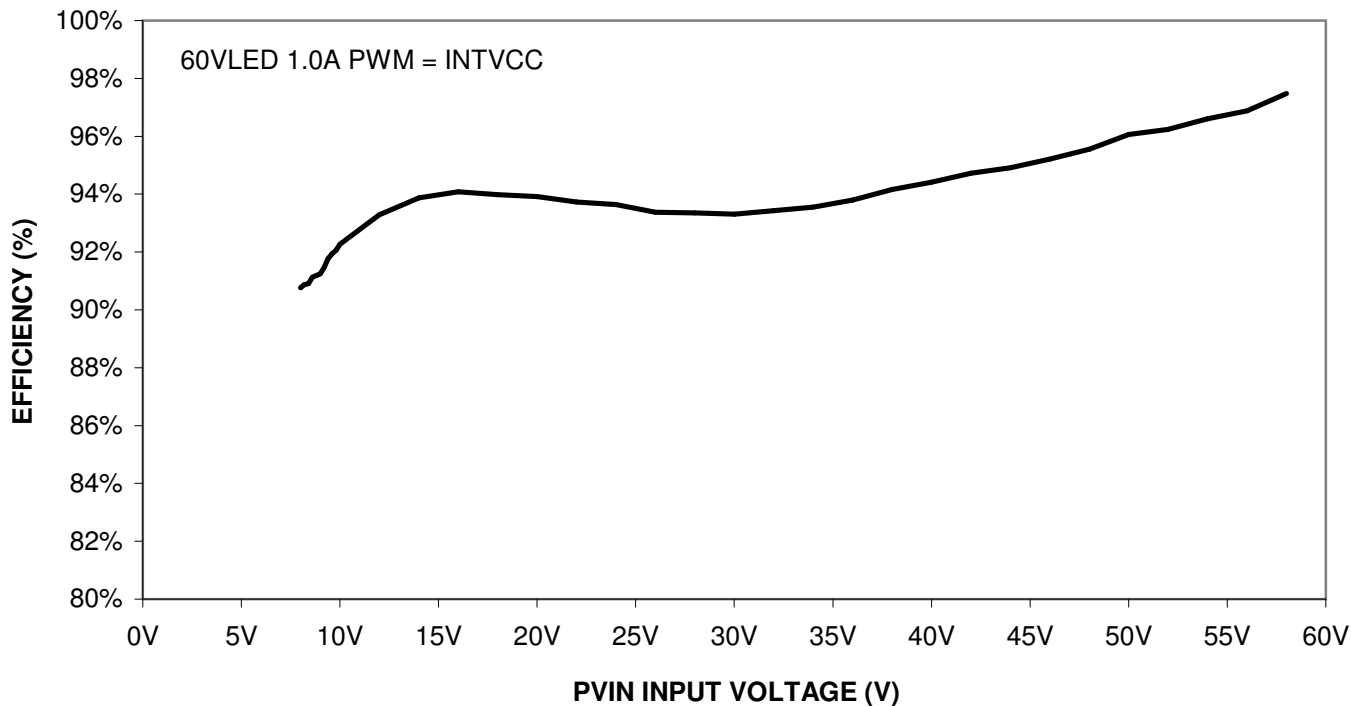# QUICK START PROCEDURE



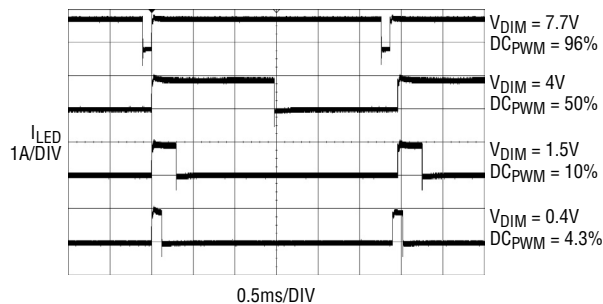**Figure 2. DC1772A Efficiency with 60V LEDs at 1A and 100% PWMOUT Duty Cycle**



**Figure 3. DC1772A 300Hz PWM Dimming Waveforms at Different PWMOUT Duty Cycles**
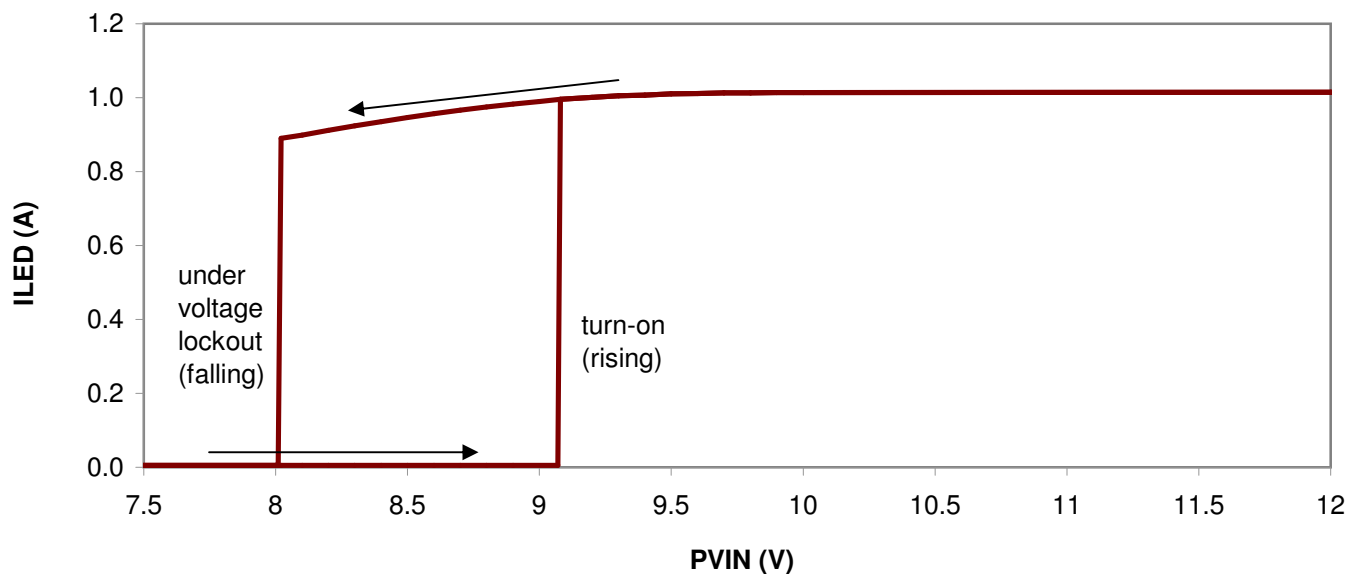
# QUICK START PROCEDURE



**Figure 4. DC1772A CTRL LED Current Foldback at Low PVIN with UVLO Falling and Rising**

# PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|------|-----|-----------|------------------|--------------------------|
| **Required Circuit Components** | | | | |
| 1 | 2 | C1, C10 | Cap., X7S 4.7µF 100V 10% 1210 | TDK C3225X7S2A475K |
| 2 | 4 | C2, C3, C11, C12 | Cap., X7R 2.2µF 100V 10% 1210 | TDK C3225X7R2A225K |
| 3 | 1 | C4 | Cap., X7R 1µF 100V 20% 1206 | TDK C3216X7R2A105M |
| 4 | 1 | C5 | Cap., X5R 1µF 10V 10% 0603 | AVX, 0603ZD105KAT2A |
| 5 | 1 | C6 | Cap., X7R 4700pF 25V 20% 0603 | AVX, 06033C472MATAT2A |
| 6 | 1 | C7 | Cap., X5R 0.01µF 16V 20% 0603 | AVX, 0603YD103MAT2A |
| 7 | 1 | C8 | Cap., X7R 0.047µF 50V 10% 0603 | AVX, 06035C473KAT2A |
| 8 | 1 | D1 | Schottky Diode 5A PowerDi5 | Diodes Inc. PDS5100H |
| 9 | 1 | L1 | Inductor, 10µH HC9-SERIES/COOPER | Cooper Bussmann, HC9-100-R |
| 10 | 1 | M1 | MOSFET N-Chan., 100V | Infineon, BSC123N08NS3G |
| 11 | 1 | M2 | MOSFET N-Chan., 100V | Siliconix Si2328DS-T1-GE3 |
| 12 | 1 | RS1 | Res., Chip., 0.008Ω 1/2W 1% 2010 | Vishay WSL20108L000FEA |
| 13 | 1 | RS2 | Res., Chip., 0.25Ω 1/2W 1% 1206 | Vishay WSL1206R2500FEA |
| 14 | 1 | R1 | Res., Chip, 499k 0.06W 1% 0402 | Vishay CRCW0402499KFKED |
| 15 | 1 | R2 | Res., Chip, 90.9k, 0.06W 1% 0402 | Vishay CRCW040290K9FKED |
| 16 | 1 | R3 | Res., Chip, 1M, 0.1W 1% 0603 | Vishay CRCW06031M00FKED |
| 17 | 1 | R4 | Res., Chip, 18.2k, 0.06W 1% 0402 | Vishay CRCW040218K2FKED |
| 18 | 1 | R5 | Res., Chip 10k, 0.06W 5% 0402 | Vishay CRCW040210K0JKED |
| 19 | 1 | R6 | Res., Chip, 29.4k, 0.06W 1% 0402 | Vishay CRCW040229K4FKED |
| 20 | 1 | R7 | Res., Chip 1M, 0.06W 5% 0402 | Vishay CRCW04021M00JKED |
| 21 | 1 | R8 | Res., Chip, 140k, 0.06W 1% 0402 | Vishay CRCW0402140KFKED |
| 22 | 1 | R9 | Res., Chip 100k, 0.1W 5% 0603 | Vishay CRCW0603100KJKEA |
| 23 | 1 | R10 | Res., Chip, 124k, 0.1W 1% 0603 | Vishay CRCW0603124KFKED |
| 24 | 1 | U1 | I.C., LED Driver MSOP(16)-MSE | Linear Tech. Corp. LT3761EMSE |
| **Optional Electrical Components** | | | | |
| 1 | 0 | C9, C13(OPT) | Cap., 1210 | |
| 2 | 0 | C14, C15 (OPT) | Cap., 0603 | |
| 3 | 0 | D2 (OPT) | Rectifier, ESIC SMA | |
| 4 | 0 | D3 (OPT) | Diode, 1N4148W, SOD-123 | |
| 5 | 0 | M3 (OPT) | MOSFET N-Chan., SOT23 | (OPT) |
| 6 | 0 | M4 (OPT) | MOSFET P SO8-PWR | (OPT) |
| 7 | 0 | Q1, Q2, Q3 (OPT) | PNP SOT23 | (OPT) |
| 8 | 1 | R11 | Res., Chip, 0Ω, 1206 | Vishay CRCW12060000Z0EA |
| 9 | 1 | R12 | Res., Chip 0Ω, 0603 | Vishay CRCW06030000Z0ED |
| 10 | 0 | R13, R17, R19-22 (OPT) | Res., 0402 | |
| 11 | 0 | R14, R24 (OPT) | Res., 0805 | |
| 12 | 0 | R15 (OPT) | Res., 1206 | |
| 13 | 0 | R16, R18, R23, R25-R27 (OPT) | Res., 0603 | |
| **Optional Hardware** | | | | |
| 1 | 14 | E1-E14 | Turret, Testpoint | Mill Max 2501-2-00-80-00-00-07-0 |

dc1772af

6

C9
OPTIONAL for BUCK MODE
OPT
1210

OUT

L1
10uH
HC9-100-R
COOPER

D1
PDS5100H

OUT

RS2
0.25
1%
1/2W
1206

LED +
60VLED
1A

PVIN
8V - 60V

PVIN

C10
4.7uF
100V
1210

C1
4.7uF
100V
1210

R11
0
1206

C2
2.2uF
100V
1210

C3
2.2uF
100V
1210

C11
2.2uF
100V
1210

C12
2.2uF
100V
1210

C13
OPT
1210

M4
OPT

OUT
R15
OPT
1206

VIN
8V - 60V

C4
1uF
100V
1206

M1
BSC123N08NS3

R3
1.0M
1%
0603

Q2
OPT

R14
OPT
0805

D2
OPT

SOT23

OUT
R16
OPT
0603

PGND

R1
499k
1%

RS1
0.008
2010

FB

R13
OPT.

R25 OPT
0603

EN/UVLO

VIN    GATE  SENSE    FB

R4
18.2k
1%

M3
OPT

OPENLED

C15
OPT

OPTIONAL for SHORT CIRCUIT

OUT
R17
OPT

R7
1M
1%

R2
90.9k
1%

14    16    15

12    EN/UVLO

7    VREF

R22
OPT

U1
LT3761EMSE

2

ISP    4

C14
OPT

LED -

M2
Si2328DS

CTRL

6    CTRL

ISN    3

R23
OPT    0603

R12
0    0603

R24
OPT
0805

INTVCC

R8
140k
1%

13    INTVCC

PWMOUT    1

PWM

R9
100k
0603

C5
1uF
10V

9    OPENLED

PWM    8

C8
0.047uF

R18
OPT
0603

INTVCC
Q3
OPT

FB

OUT

OPENLED

DIM/SS  VC    GND    RT

SOT23

R21
OPT

R19
OPT

DIM

R10
124k
0603

10    5    17    11

R5
10k

R6
29.4k
1%

INTVCC

R27
OPT
0603

R26
OPT
0603  D3

PVIN  R20
OPT

Q1
OPT
SOT23

GND

C7
0.01uF

C6
4700pF

350kHz

LED+

FB

GND

OPT

OPTIONAL for SHORT CIRCUIT

OPTIONAL LEVEL SHIFT for BUCK
MODE or BUCK-BOOST MODE

NOTE: UNLESS OTHERWISE SPECIFIED
RESISTORS ARE IN 0402.
CAPACITORS ARE IN 0603.

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